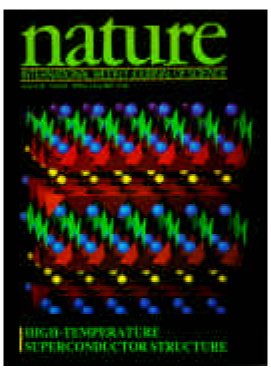
Office of Science
Basic Energy Sciences

"Serving the Present, Shaping the Future"

http://www.sc.doe.gov/production/bes/bes.html

The Basic Energy Sciences (BES) Program supports fundamental research in materials sciences and engineering, chemistry, geosciences, and molecular biosciences. In FY 2000, the Program funded research in more than 150 academic institutions located in 48 states and in 13 DOE laboratories located in 9 states. The BES Program also supports world-class scientific user facilities, including four synchrotron radiation light sources, three neutron scattering facilities, and four electron-beam micro characterization centers. Annually, 8,000 researchers from academia, industry, and federal laboratories perform experiments at these facilities. Under construction is the Spallation Neutron Source (SNS), a $1.4 billion next-generation neutron scattering facility.

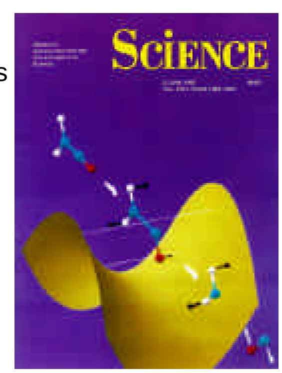
The Opportunity: In the past century, the triumphs of science, which improved our lives immeasurably, were elegant and simple solutions to complex problems that had puzzled scientists for millennia. We discovered and characterized the atomic building blocks of matter, the elementary excitations in materials, and the fundamentals of chemical reactivity. We used this knowledge to design, synthesize, and characterize simple molecules and to use them as components of, for example, alloys, ceramics, and catalysts. The next millennium leads us into a more complex world of research with unprecedented opportunities. Here, large complicated structures can be designed atom by atom for desired characteristics. Here, also, chemical reactivity can be predicted and controlled. New tools, new understanding, and a developing convergence of the BES-supported disciplines will allow us to ask and solve questions that were previously the stuff of science fiction.



The Challenge: ***Science at the nanoscale.*** Can we achieve a fundamental understanding of nanoscale assemblies of materials – structures 1000 times smaller than a human hair? At the nanoscale, materials have properties distinctly different from those of the bulk, and lessons learned from 20th century studies do not apply.

Materials by design. Can we design materials having predictable and yet, often unusual properties? This will require "bottoms-up" atomic and molecular design, the use of nanostructured materials, novel routes for materials synthesis and processing, and parallel fabrication approaches.

Functional molecular systems. Can we design and construct multi component molecular devices and machines having desired properties – optical, mechanical, catalytic, electrical, tribological? These might form the basis of systems such as nanometer-scale chemical factories, molecular pumps, sensors, and self-assembling electronic/photonic devices.



Chemical reactivity. Can we predict and control chemical reactivity – the making and breaking of chemical bonds to fabricate desired products while minimizing or eliminating unwanted products? The convergence of chemical catalysis and biological catalysis coupled

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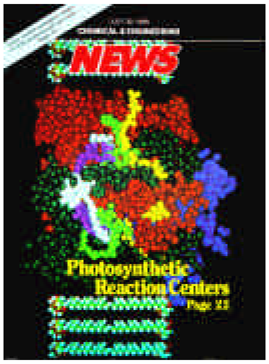
with new, exotic techniques, such as laser-based control, may make it possible to control reactivity with a precision found only in nature and to fashion novel products not seen in nature.



***The molecular foundations of natural processes*.** Can we harness, control, or mimic the exquisite complexity of natural processes? Living organisms represent the most sophisticated use of the elements to create materials and functional complexes through chemical processing. Nature's achievements allow us to set goals for the development of materials and systems with the enhanced properties, including the ability to self-assemble, self-repair, sense, respond, and evolve.

Scaling in space and time. Can we develop the tools to visualize and predict phenomena spanning the length scales and time scales of natural phenomena? The challenges are formidable. Spatial scaling involves lengths ranging from that of the atom, to thousands of atoms, to the bulk phase, and, finally, to the macroscale. Temporal scaling involves times ranging from those of chemical reactions (femtoseconds) to geologic times (millennia).

FY 2002 Investment Plan:

The BES Program will strengthen core competencies to address outstanding scientific challenges. In the areas of nanoscale science, engineering, and technology research, the BES Program will continue the research directions initiated in FY 2001 and explore concepts and designs for Nanoscale Science Research Centers, which will provide unique, state-of-the-art nanofabrication and characterization facilities to the scientific community. Also of high priority is the continuation of the construction of the SNS to provide the next-generation, short-pulse spallation neutron source for neutron scattering.

The Benefits:

Research in materials sciences and engineering leads to the development of materials that improve the efficiency, economy, environmental acceptability, and safety in energy generation, conversion, transmission, and use. Research in chemistry leads to the development of advances such as efficient combustion systems with reduced emissions of pollutants; new solar photo conversion processes; improved catalysts for the production of fuels and chemicals; and better separations and analytical methods for applications in energy processes, environmental remediation, and waste management. Research in geosciences contributes to the solution of problems in multiple DOE mission areas, including reactive fluid flow studies to understand contaminant remediation and seismic imaging for reservoir definition. Finally, research in the molecular and biochemical nature of plant growth aids the development of renewable biomass resources.